Streamflow Requirements for Protection of Fish and Habitat in Massachusetts

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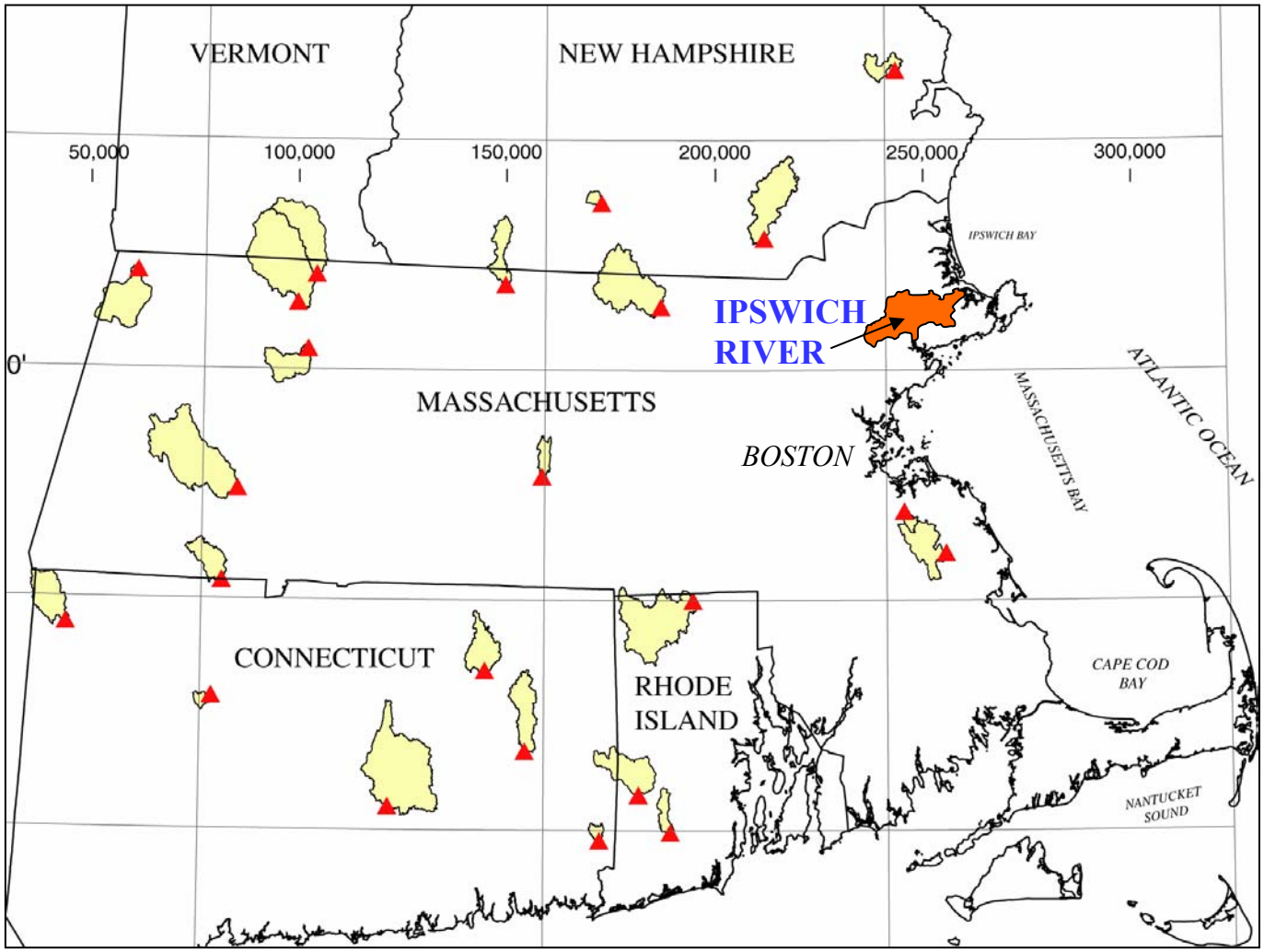
Relations among stream habitat, fish communities, and hydrologic conditions were investigated in:

- 23 relatively-natural-flow rivers in Southern New England, and
- The Ipswich River, a highly flow-stressed river in northeastern MA



The Ipswich River basin supplies water to 330,000 people and 23 municipalities

IPSWICH RIVER

No-flow conditions in the headwaters of the Ipswich River caused fish kills in reaches adjacent to where ground water is withdrawn for public water-supply.

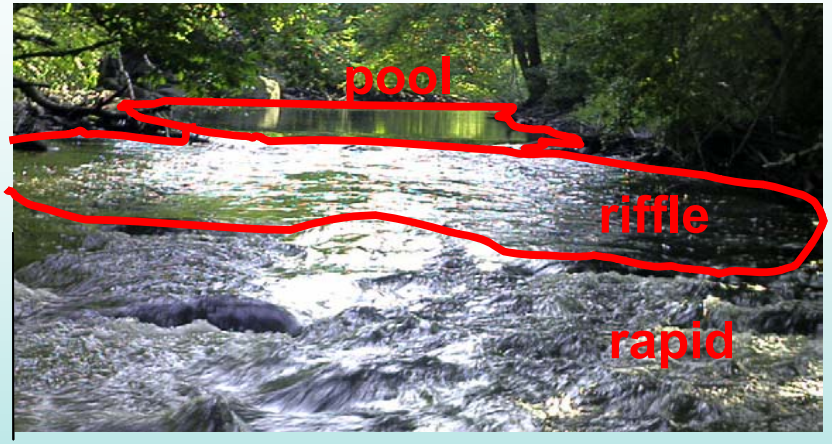
Ipswich River, Reading/North Reading, D.A. = 18 mi^2

What streamflows are needed to support river fish communities ?

Ipswich R., Ipswich, MA Drainage area = **130** mi^2

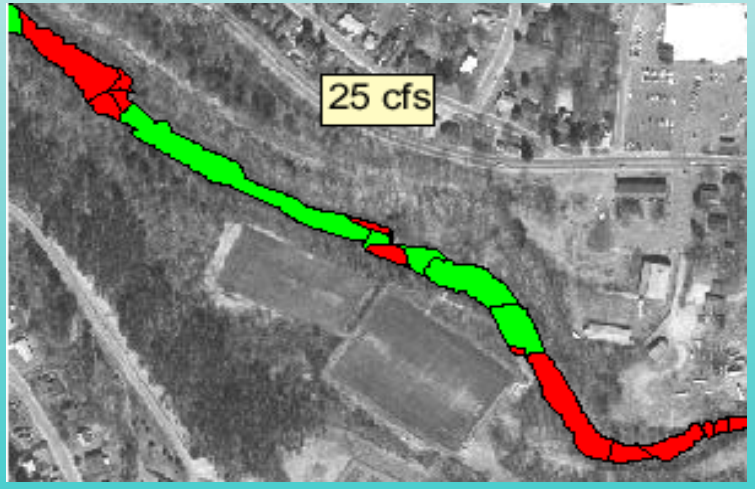
Northeast Instream Habitat Program

University of Massachusetts – Department of Natural Resources Conservation



FALLFISH

Presence (76%)		Beta
	BOULDER	1.95
	SHADING	-1.07
	DEPTH 0-25 cm	-1.76
	VELOCITY 45-60 cm/s	1.06
	RUN	-0.57
High abundance (60%)		
	Overhanging vegetation	-0.97



http://www.NEIhp.org

MDFW Fish Community Assessment

27 mainstem sampling locations, 4745 fish

Fish were classified into habitat-use groups*:

- **Fluvial specialists** (FS): Species that require flowing-water for all of their life-cycle

Ex. Brook trout

- **Fluvial dependents** (FD): Species that require flowing-water for part of their life-cycle

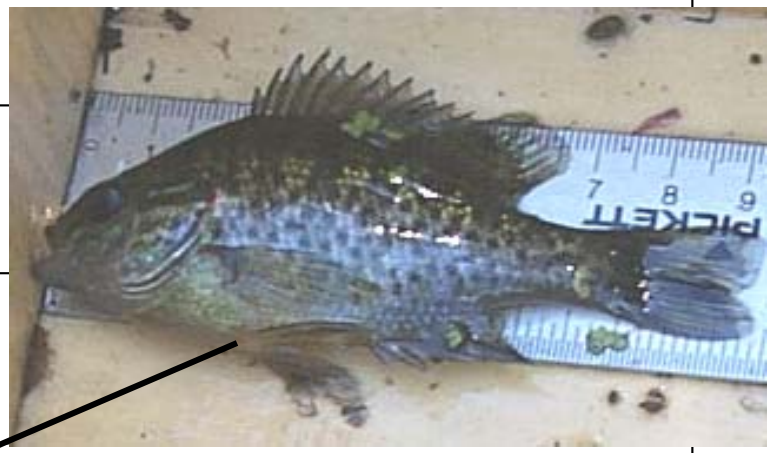
Ex. White sucker

- **Macrohabitat generalists** (MG): species that do not require flowing water conditions

Ex. Redfin pickerel

* Habitat-Use Classifications developed by Mark Bain, Cornell University

Results showed that the mainstem of the Ipswich River was dominated by macrohabitat generalist species.



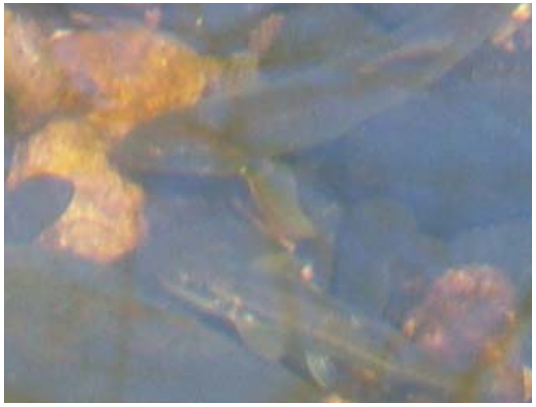
Relative abundance of fish in the Ipswich River mainstem

Fluvial or “River” Fish were present only in low numbers

Fallfish

Creek Chubsucker

Some fluvial species that were expected to be in the Ipswich were found in only a few samples or not at all

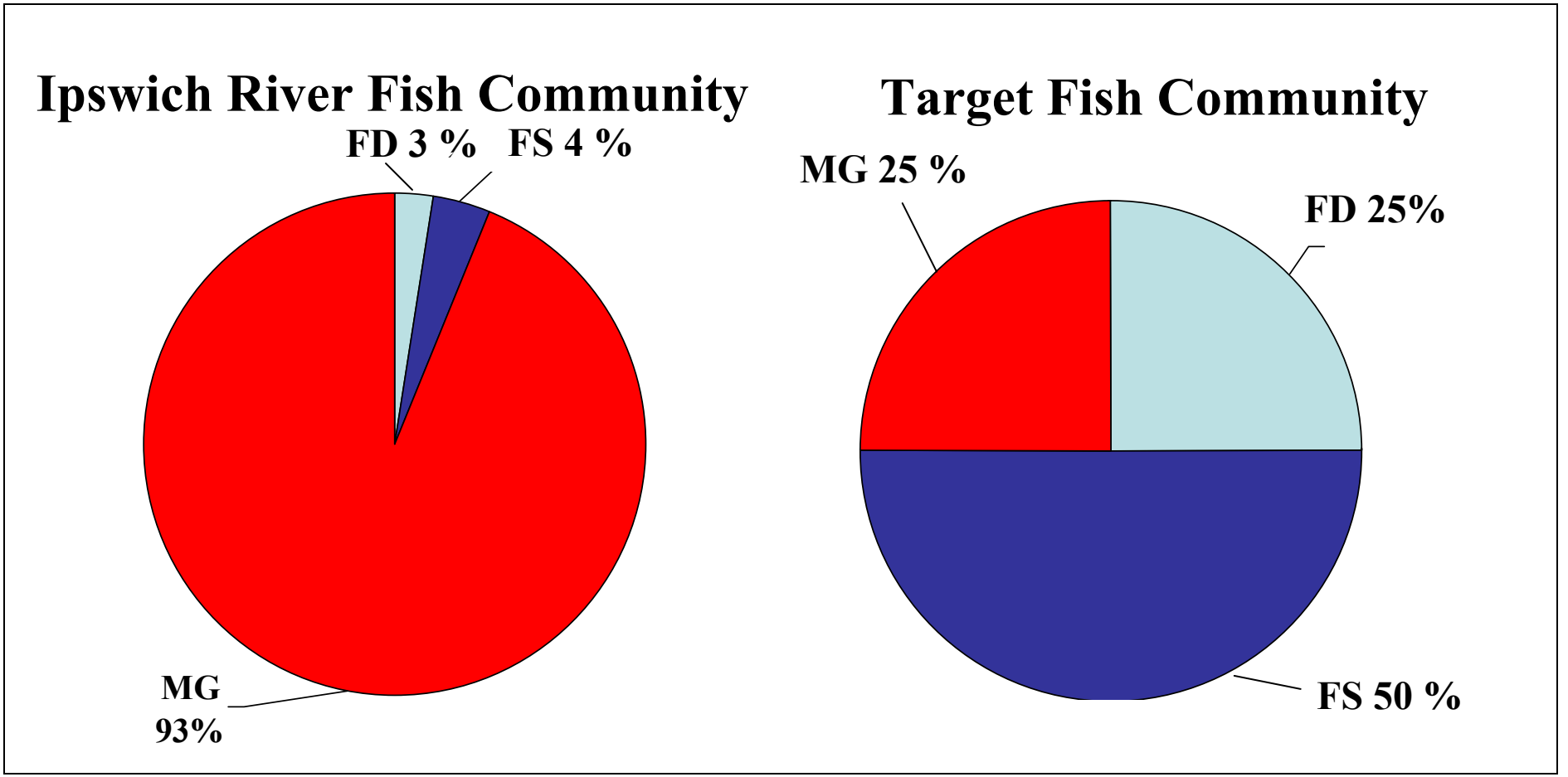


Longnose dace

Tesselated Darter

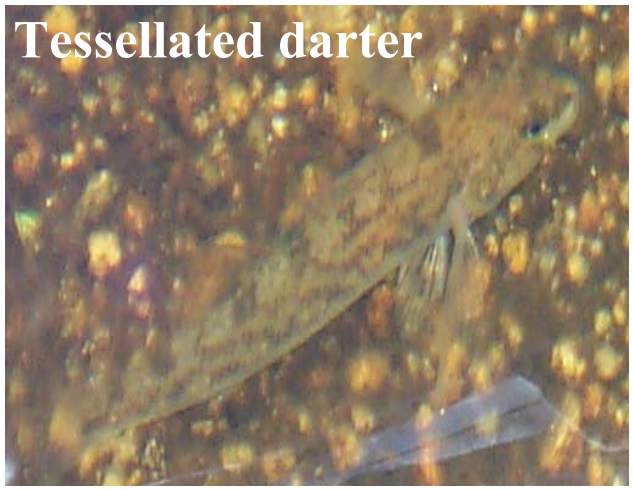
Common Shiner

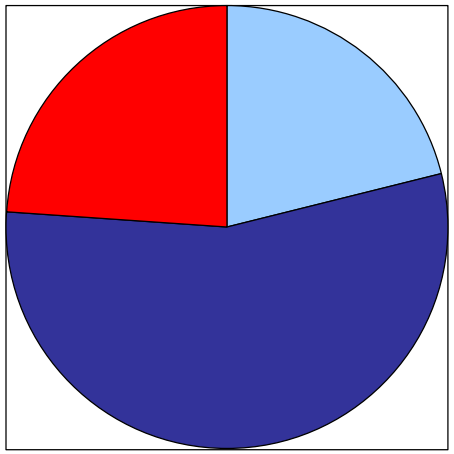
Comparison of the Ipswich fish community to a Target Fish Community (Bain and Mexler, 2000)

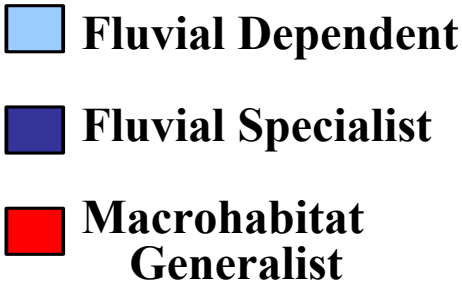


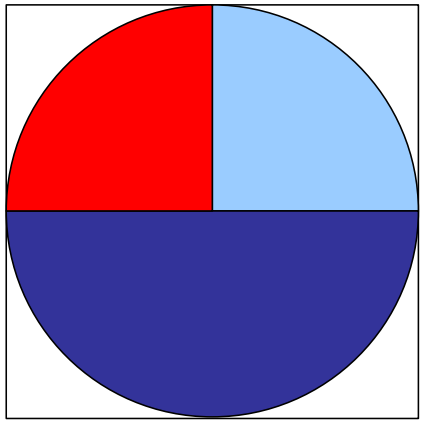
"Rivers Should Have River Fish"

Fish communities in the 23 relatively-natural-flow rivers were similar to the Target Fish community









Fish community composition near 10 Index gages

Target Fish Community for a natural river in Southern New England

Ipswich Habitat Assessment

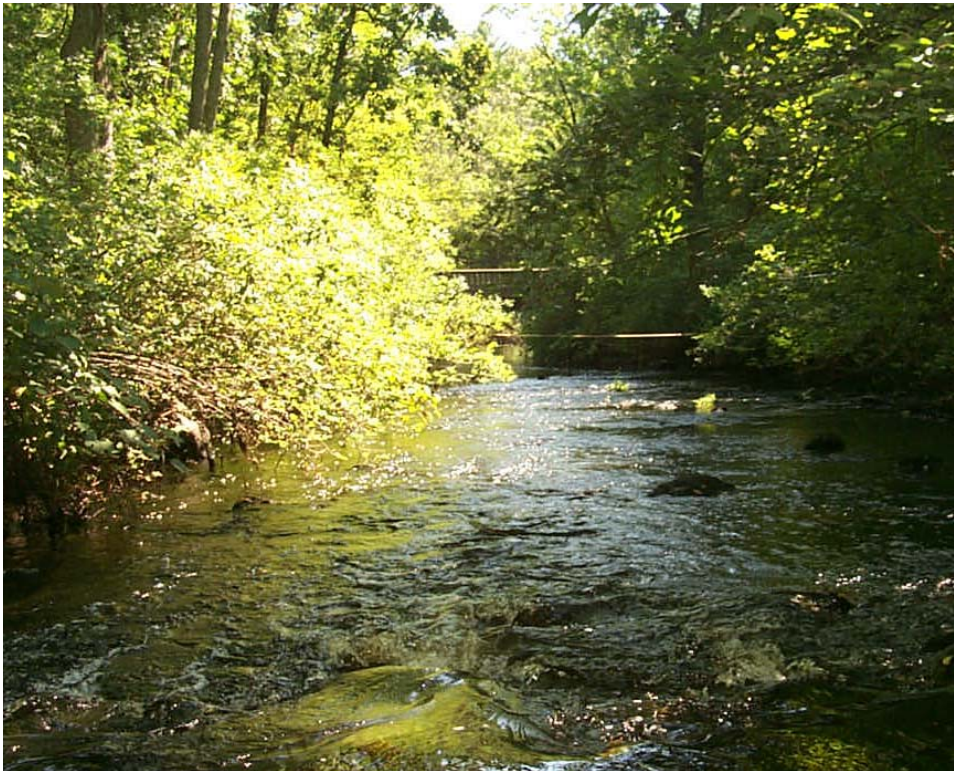
- The Ipswich is predominately a low-gradient river.

- The dominant habitat structure is stream-margin habitat created by woody debris, undercut banks, and overhanging vegetation.

- Much of the stream-margin habitat does not provide cover during low flows when the edge of water pulls away from the bank.

Riffle habitats are the first habitat type to show significant habitat losses during periods of low flow

Flows that maintain habitat in riffles keep the river from segmenting during low flows, and also provide sufficient depth to provide stream-margin habitat in nearby reaches.



A variety of methods were used for assessing streamflow requirements for habitat protection

(1) <u>Standard-setting Hydrologic methods</u> based on streamflow records and statistics

a) Tennant Method

b) New England Aquatic Base Flow (ABF) Method

(2) <u>Standard setting, field-based methods</u> based on hydraulic criteria in riffles

c) The Wetted-Perimeter Method

d) The R2Cross Method

(3) <u>Diagnostic methods for assessing flow regimes</u>

e) Range of Variability Approach (RVA)

(a) The **Tennant Method** – streamflow requirements determined by a percentage of the mean annual flow

Habitat condition for small streams	**Percent of Mean Annual Flow April-Sept**
Flushing flows	200%
Optimum range	60-100%
Outstanding	60%
Excellent	50%
Good	40%
Fair (most substrate submerged)	30%
Poor (half or more substrate exposed)	10%
Severe degradation	< 10%

(b) The **New England Aquatic Base Flow (ABF) Method**

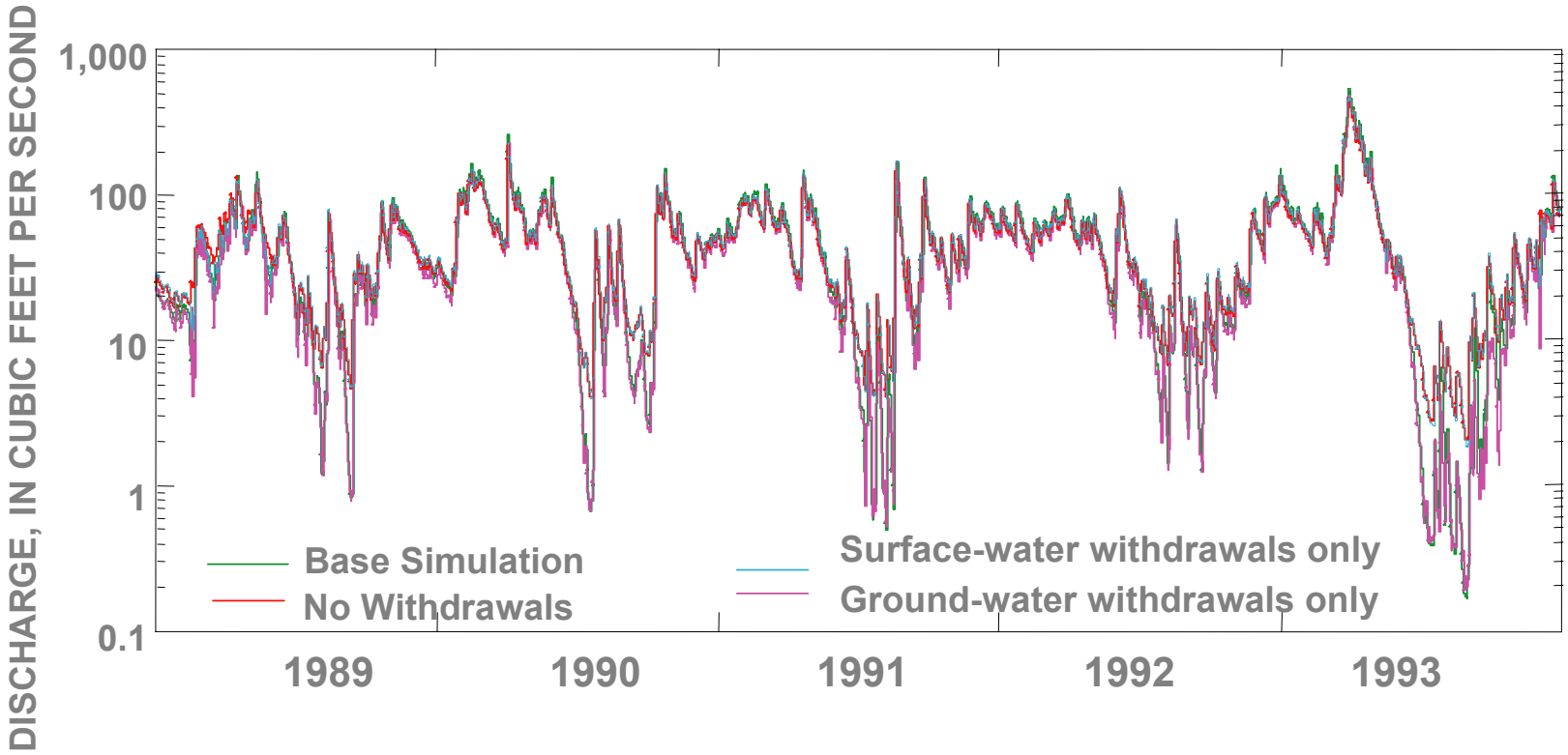
• For gaged, unregulated sites, summer streamflows are determined by the median of the August monthly-mean flows

• For ungaged or regulated sites, default streamflows are determined by default flows:

Season	Months	Streamflow
Summer	Jun to Oct	0.5 cfsm*
Fall/Winter	Oct to Mar	1.0 cfsm
Spring	Apr-Jun	4.0 cfsm

*cfsm = cubic feet per second per square mile drainage area

Streamflows were simulated by an HSPF rainfall-runoff model under no withdrawals and 1991 land-use conditions



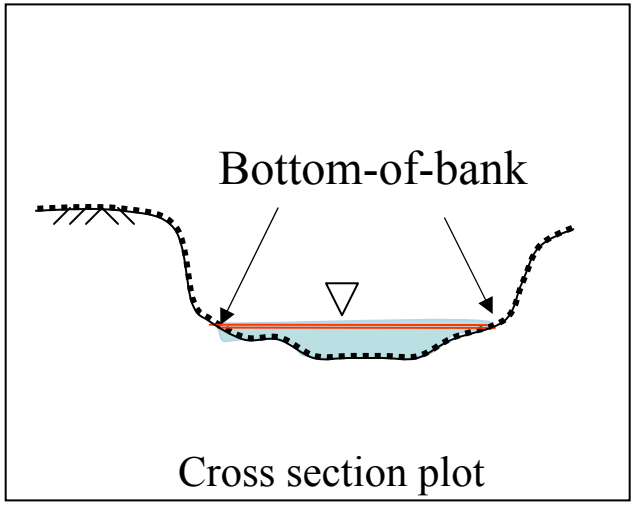
WRIR 00-4029 A Precipitation-Runoff Model for Analysis of the Effects of Water Withdrawals on Streamflow, Ipswich River Basin, MA

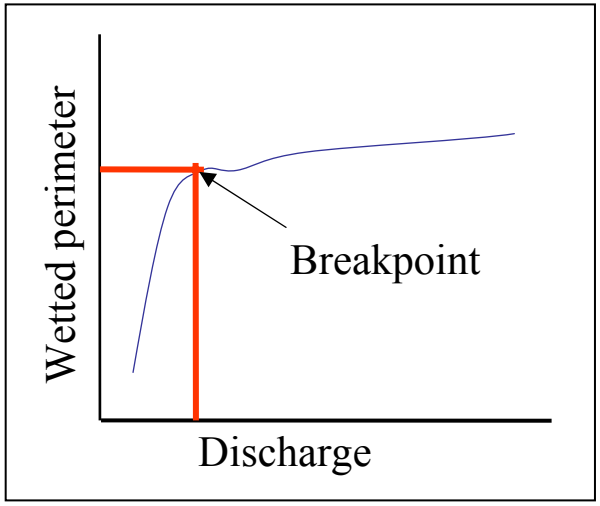
For the riffle based methods:

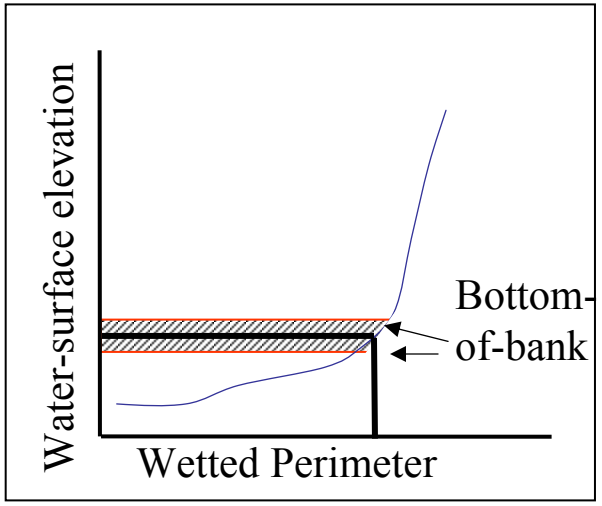
- Calibrated water-surface profile models (WSPRO, HEC-RAS) were developed.

- Model output was used to simulate hydraulic parameters

(c) The **Wetted Perimeter Method** determines streamflow requirements as the breakpoint in the relation between wetted perimeter and discharge.



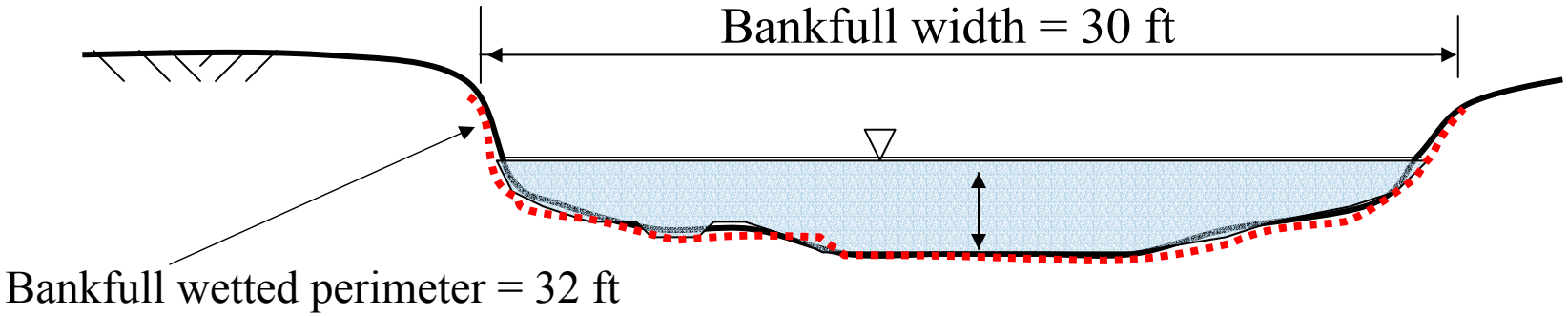




(d) **The R2Cross** method uses predetermined criteria for three hydraulic parameters:

- mean depth
- percentage of bankfull wetted perimeter
- average velocity

Example



Mean depth	0.30 ft
Mean velocity	1 ft/s
Wetted perimeter	16 ft

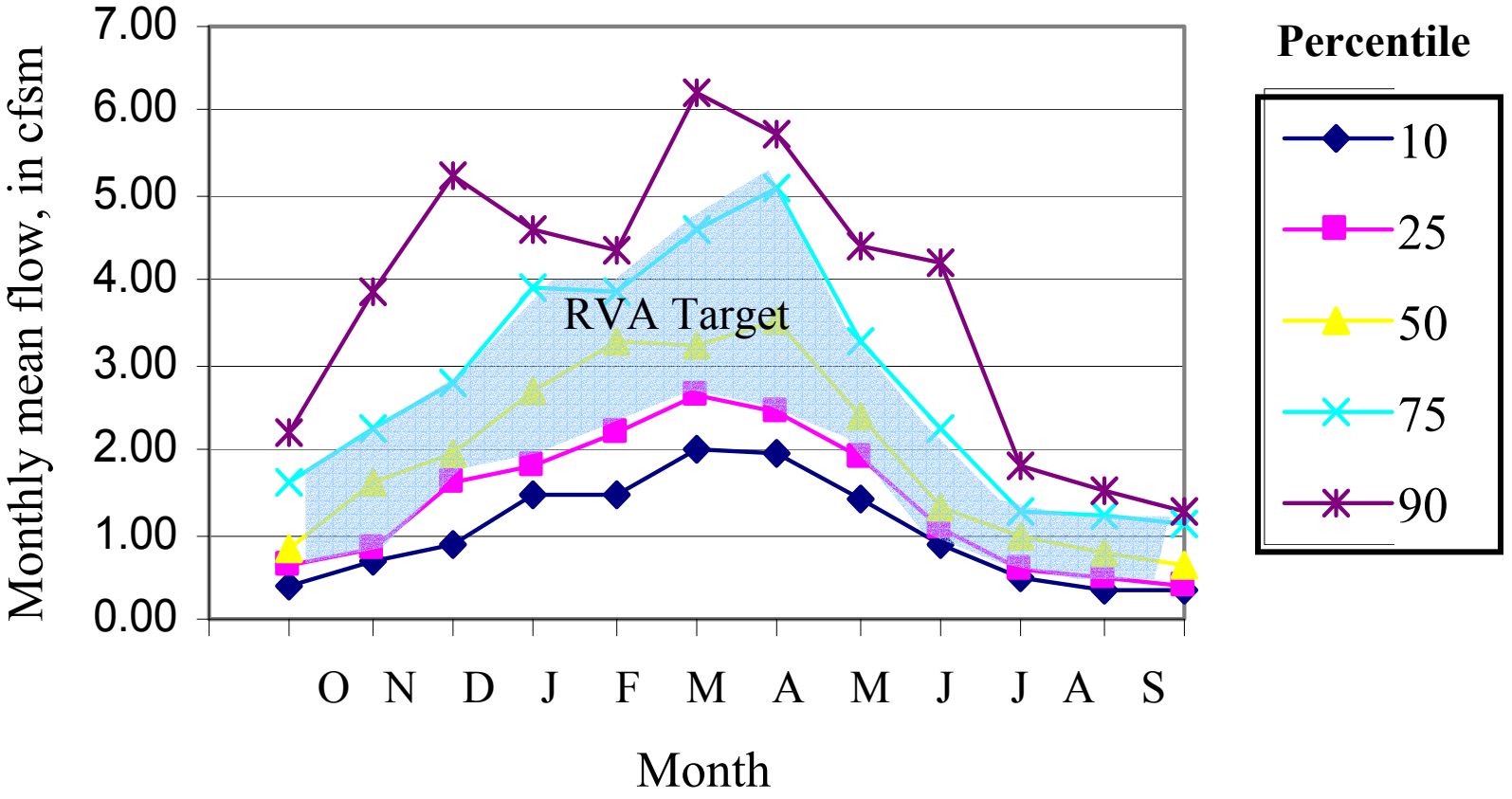
(e) The **Range of Variability (RVA) method** recommends Flow–Management Targets that mimic natural flows

A natural flow regime provides many functions important for the ecological integrity of rivers:

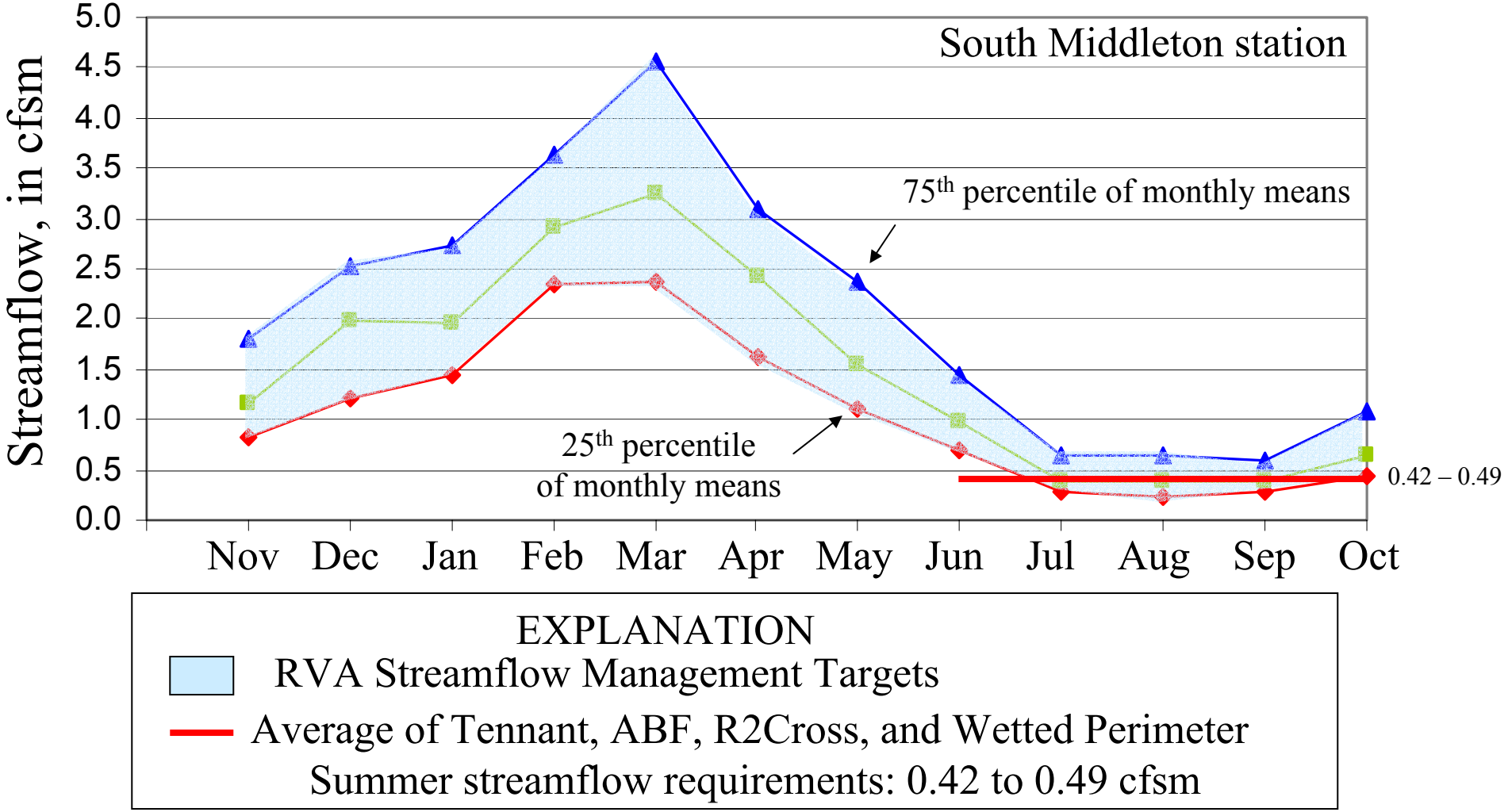
- Maintains river channel
- Mobilizes sediment
- Restores aquatic habitat
- Provides migration and spawning clues for fish

(e) The **Range of Variability (RVA) method**

Flow–Management Target is defined as the range between the 25th and 75th percentiles of monthly mean flows



Ipswich River Results



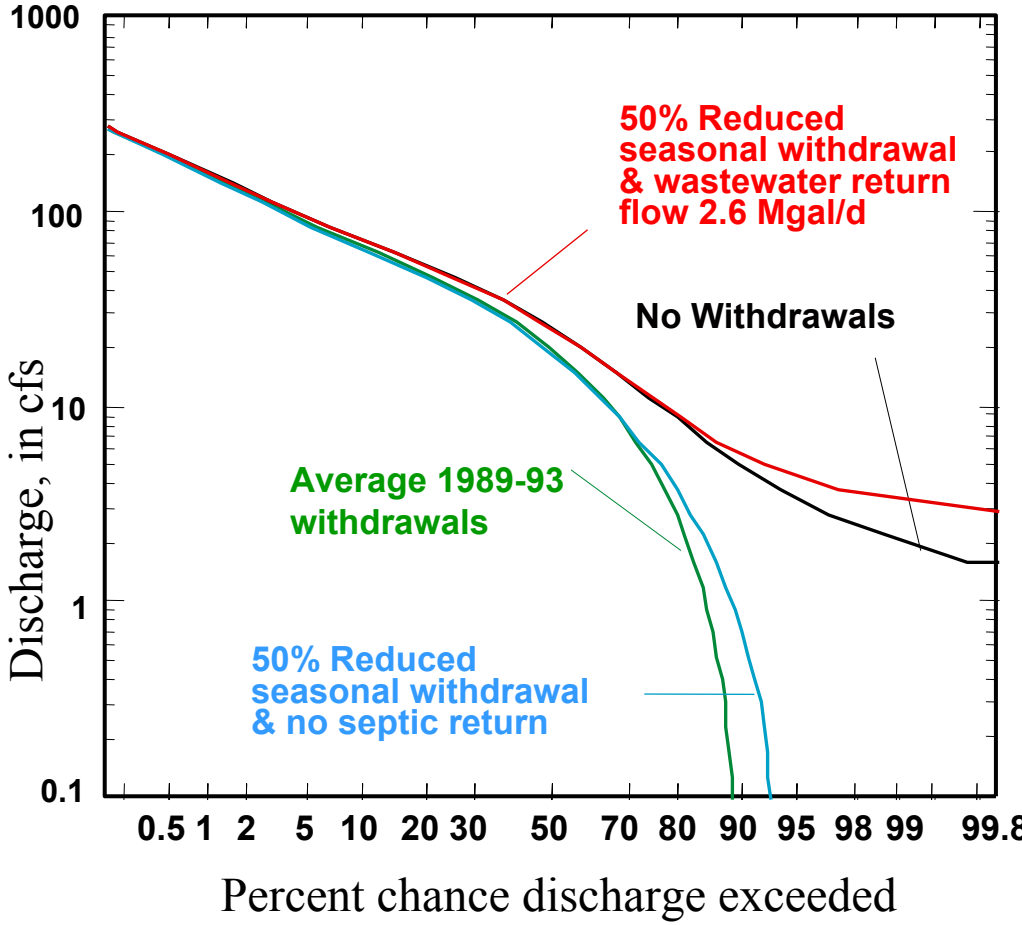
WRIR 01-4161 Assessment of Habitat, Fish Communities, and Streamflow Requirements for Habitat Protection, Ipswich River, Massachusetts, 1998-99

The HSPF model was used to evaluate the effects of water management alternatives on streamflow

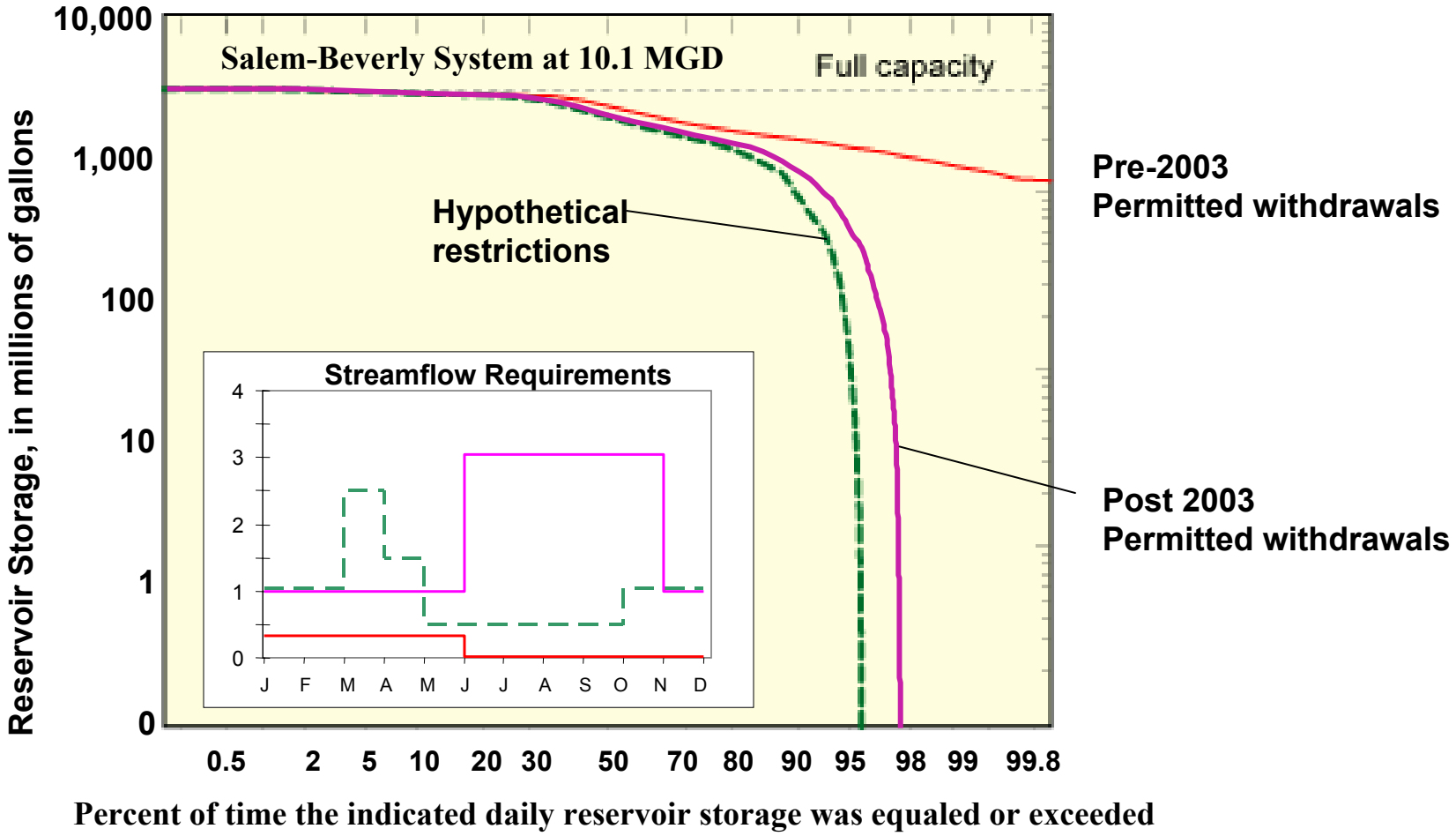
Water Management Alternatives

- Stop all withdrawals
- Ground-water withdrawals only
- No surface-water withdrawals only
- Long-term, no water-supply demands
- Long-term, undeveloped land use, and no water demands
- Long-term with 1989-93 avg. water withdrawals
- No seasonal withdrawals
- Flow-threshold-limited streamflow depletion
- Reduced seasonal withdrawals by 50 percent from May 1 to October 31
- Increased withdrawals by 20 percent
- Decreased withdrawals by 20 percent from June 1 to September 30
- Wastewater returns of 1.1, 1.5 and 1.7 Mgal/d
- No septic effluent inflow
- Reduced withdrawal by 50 percent and wastewater return flow of 2.6 Mgal/d
- Reduced withdrawal by 50 percent and no septic effluent inflow

Flow-duration curves



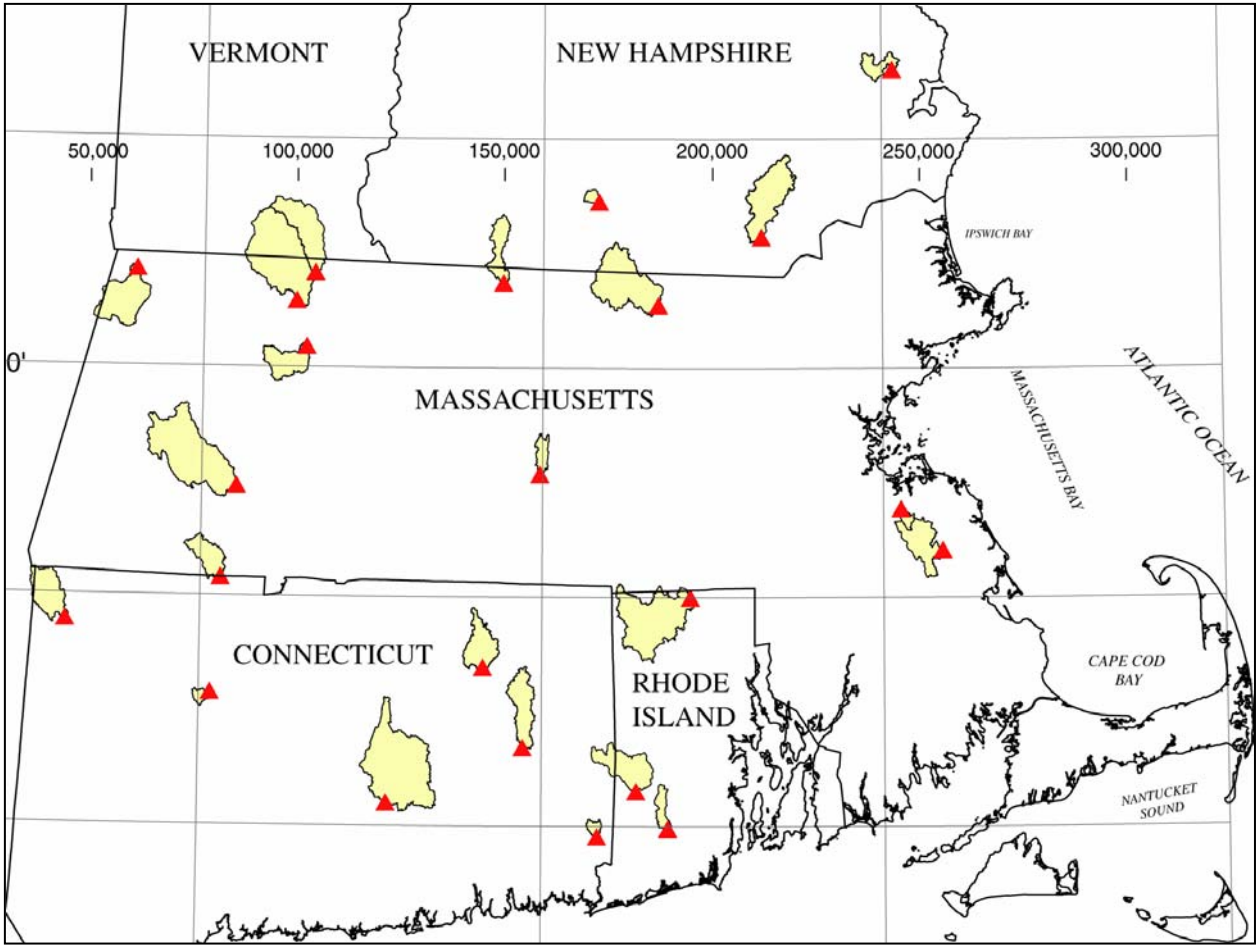
The HSPF model was used to evaluate the effects of permitted withdrawals and water management alternatives on reservoir storage and firm yields



WRIR 02-4278: Simulation of Reservoir Storage and Firm Yields of Three Surface Water Supplies, Ipswich River Basin, MA

SIR 2004-5122: Simulated Effects of the 2003 Permitted Withdrawals and Water Management Alternatives on Reservoir Storage and Firm Yields of Three Surface Water Supplies, Ipswich River Basin, MA,

A second study investigated the streamflow variability for 23 relatively-natural-flow rivers in Southern New England



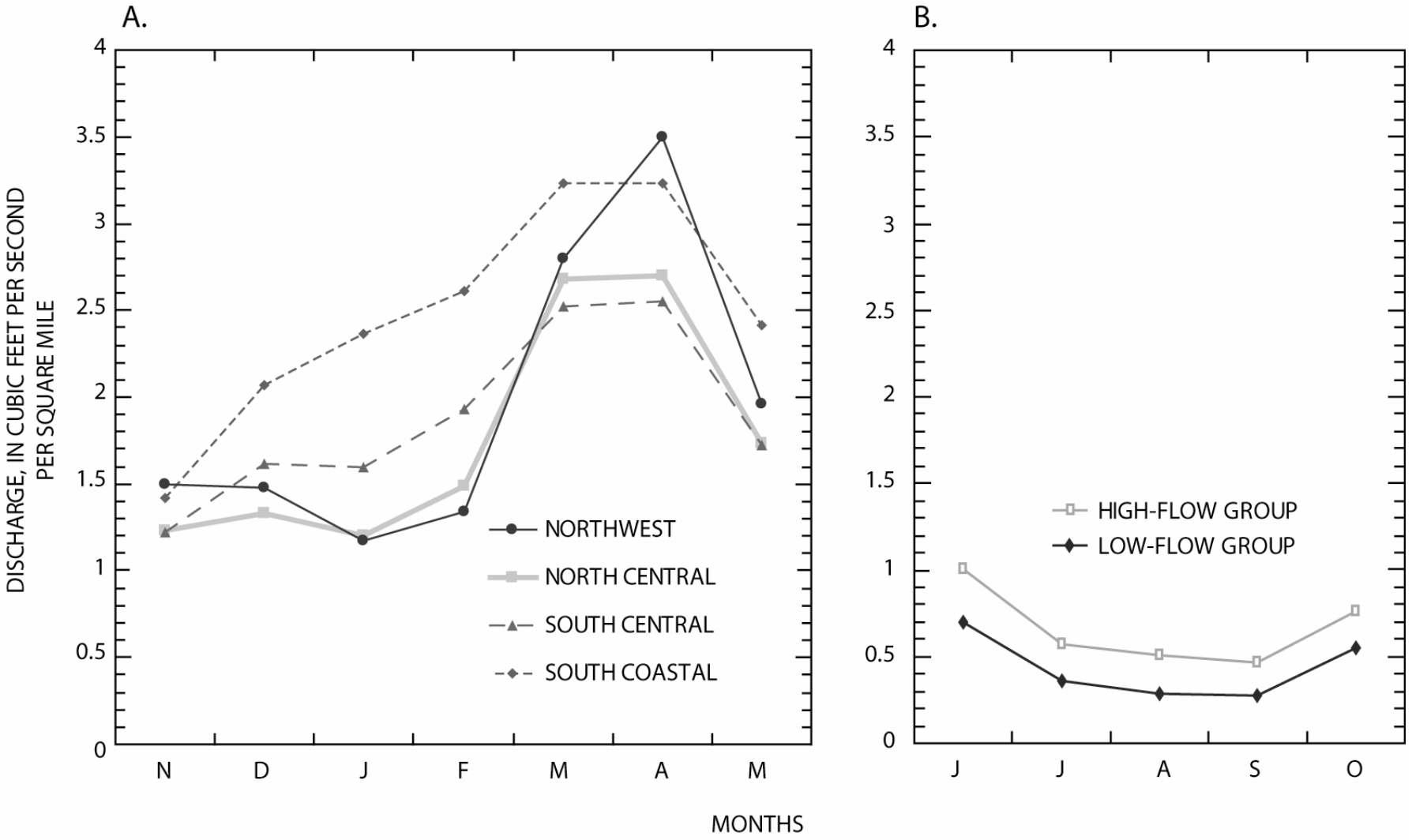
WRIR 03-4332 Evaluation of Streamflow Requirements for Habitat Protection by Comparison to Streamflow Characteristics at Index Streamflow-Gaging Stationsin Southern New England

Summer flows at the index sites went low, but they were not low for long periods, and the rivers didn't go dry.

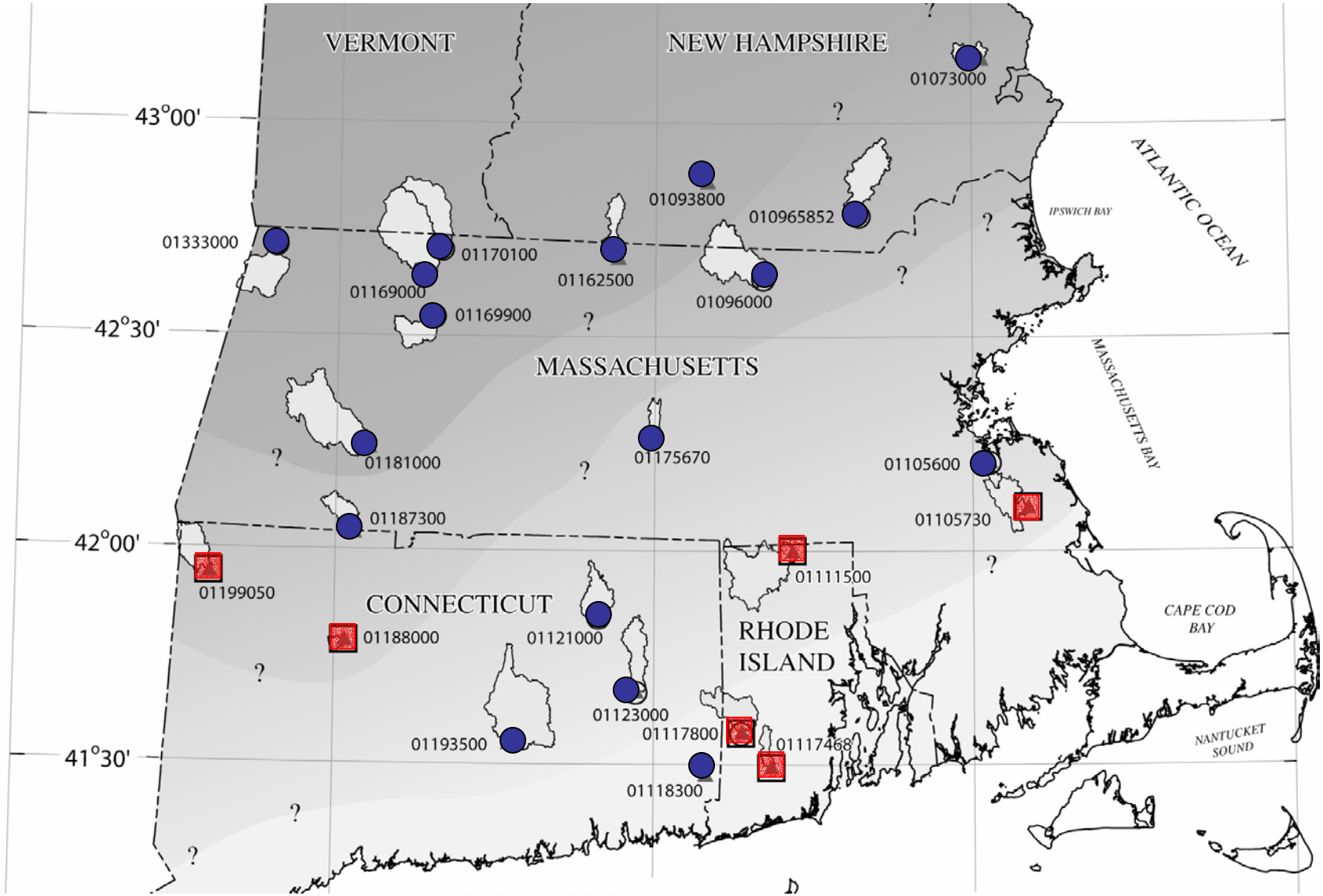
Flow regimes were characterized using median monthly flows

Flows from Nov. – May were classified by region

Flows from June – Oct. were classified by percent sand and gravel



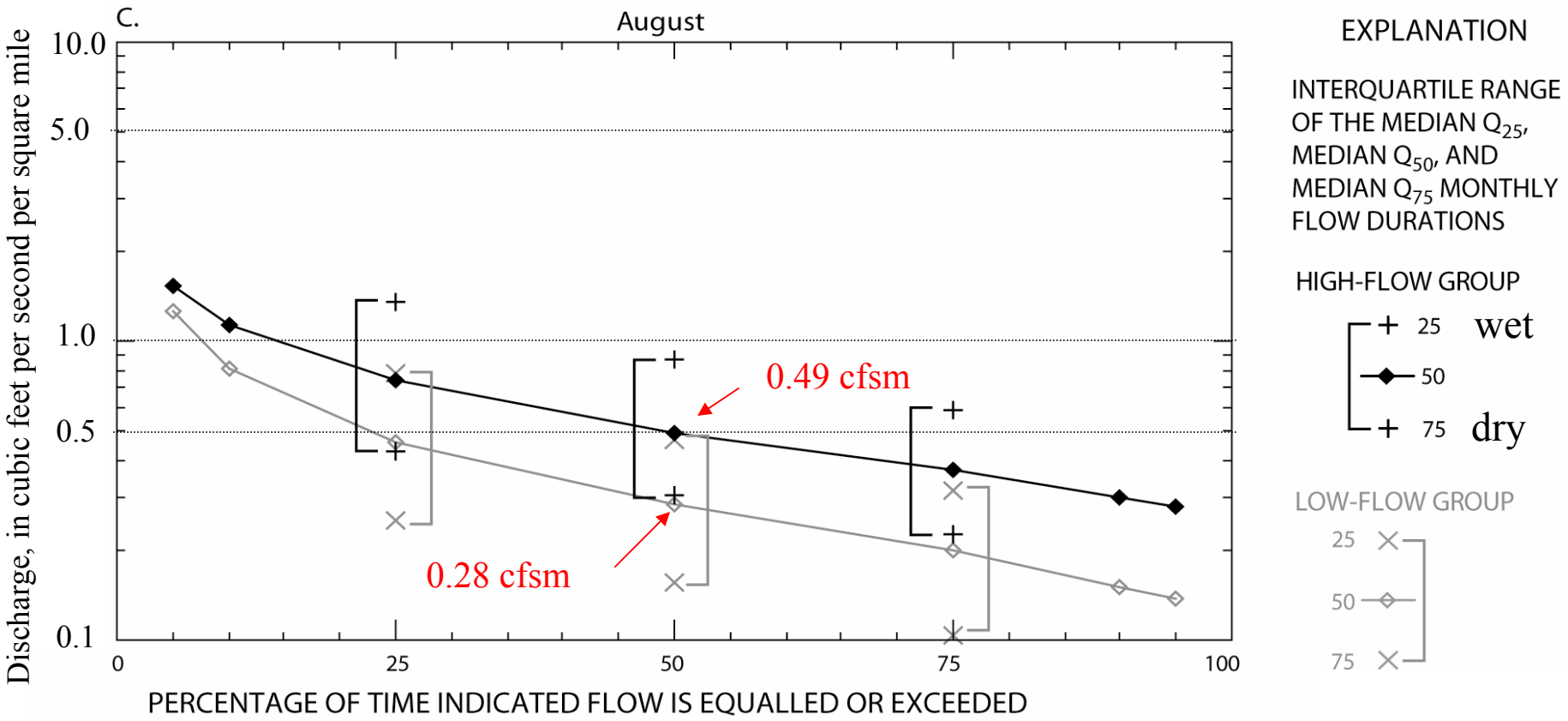
Classification of index stations in Southern New England



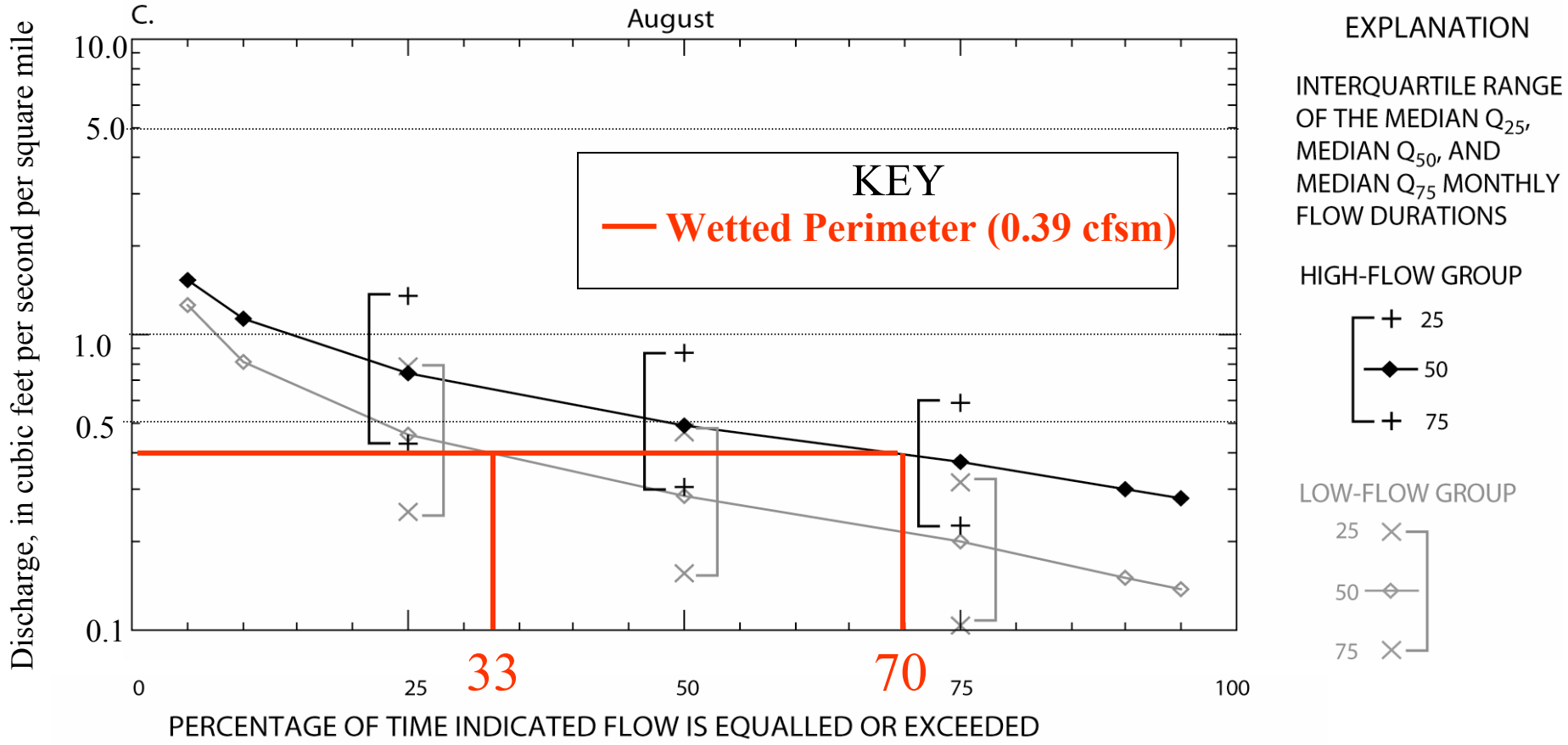
Median streamflows vary between wet and dry years.

- Monthly flow durations (Q25, Q50, Q75) show variability of streamflows within a month

- Percentiles of monthly flow durations (75th, 25th) show streamflow variability between years



Results show that streamflows differ between different types of streams, and suggest that single streamflow requirements may not be suitable for all types of streams



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Streamflow requirements and statistics determined from these studies, together with HSPF evaluations of management alternatives for balancing ecologic and water-supply needs, are being used to guide the development of instream flow policies and water-withdrawal regulations in Massachusetts